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Ecology & Environment

RY
GEOLOGY
CHICAGO AREA

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA

H. B. Willman

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ILLINOIS STATE GEOLOGICAL SURVEY
URBANA, ILLINOIS 61801
John C. Frye, *Chief*

Time Stratig			Rock Stratigraphy			GRAPHIC COLUMN	Thickness (Feet)	KINDS OF ROCK
SYSTEM	SERIES	STAGE	MEGA-GROUP	GROUP	FORMATION			
QUAT.	PLEIS.				(See fig 15)		0-350	Till, sand, gravel, silt, clay, peat, marl, loess
PENN.	DESM.			Kewanee	Carbondale		0-125	Shale, sandstone, thin limestone, coal
					Spoon		50-75	As above, but below No 2 Coal
MISS.	VAL.				Burl-Keokuk		0-700	Limestone — Only in Des Plaines Disturbance
	KIND.				Hannibal			Shale, siltstone
DEV.	UP.				Grassy Creek		0-5	Shale in solution cavities in Silurian
SILURIAN	NIAGARAN		Hunton		Racine		0-300	Dolomite, pure in reefs; mostly silty, argillaceous, cherty between reefs
					Waukesha		0-30	Dolomite, even bedded, slightly silty
					Joliet		40-60	Dolomite, shaly and red at base; white, silty, cherty above; pure at top
	ALEX.				Kankakee		20-45	Dolomite, thin beds; green shale partings
					Edgewood		0-100	Dolomite, cherty, shaly at base where thick
ORDOVICIAN	CIN.	RICH.		Maquoketa	Neda		0-15	Oolite and shale, red
					Brainard		0-100	Shale, dolomitic, greenish gray
					Ft Atkinson		5-50	Dolomite, green shale, coarse limestone
		MAY ED.			Scales		90-120	Shale, dolomitic, gray, brown, black
	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Wise Lake		170-210	Dolomite, buff, pure
					Dunleith			Dolomite, pure to slightly shaly; locally limestone
					Guttenberg		0-15	Dolomite, red specks and shale partings
		BLACKRIVERAN		Platteville	Nachusa		0-50	Dolomite and limestone, pure, massive
					Grand Detour		20-40	Dolomite and limestone; medium beds
					Mifflin		20-50	Dolomite and limestone, shaly, thin beds
					Pecatonica		20-50	Dolomite, pure, thick beds
				Ancell	Glenwood		0-80	Sandstone and dolomite, silty; green shale
					St. Peter		100-600	Sandstone, medium and fine grained; well rounded grains; chert rubble at base
	CANADIAN		Knox	Prairie du Chien	Shakopee		0-70	Dolomite, sandy; oolitic chert; algal mounds
					New Richmond		0-35	Sandstone, fine to coarse
					Oneota		190-250	Dolomite, pure, coarse grained; oolitic chert
					Gunter		0-15	Sandstone, dolomitic
CAMBRIAN	CROIXAN	TREMP.			Eminence		50-150	Dolomite, sandy
					Potosi		90-220	Dolomite; drusy quartz in vugs
		FRAN.			Franconia		50-200	Sandstone, glauconitic; dolomite; shale
					Ironton		80-130	Sandstone, partly dolomitic, medium grained
		DRESBACHIAN			Galesville		10-100	Sandstone, fine grained
					Eau Claire		370-570	Siltstone, dolomite, sandstone and shale, glauconitic
			Potsdam		Mt. Simon		1200-2900	Sandstone, fine to coarse; quartz pebbles in some beds
PRE-CAM.								Granite

The oldest and deepest rocks in the Chicago area are the Precambrian rocks, which were metamorphosed by heat and pressure at great depths in the crust of the earth. They were intruded by masses of molten rock that cooled slowly, forming granite; later they were uplifted and deeply eroded before late Cambrian time. The sub-Cambrian unconformity represents an interval of time longer than all the time since the beginning of the Cambrian Period. This unconformity is 3,000 to 5,000 feet below the surface in the Chicago area. It is a generally flat surface, but hills of harder rock are locally prominent where the unconformity is exposed in Wisconsin and Missouri (fig. 1).

Only a minor unconformity separates the Cambrian and lower Ordovician (Canadian) rocks that compose the Sauk Sequence. After deposition of the lower Ordovician rocks, the tectonic movements that disturbed major areas in the eastern part of the continent caused uplift, warping, and erosion in the Chicago area. As a result the basal middle Ordovician (Champlainian) St. Peter Sandstone truncates the lower Ordovician rocks and rests directly on Cambrian strata in the central and northern parts of the area (fig. 6). The sub-middle Ordovician unconformity is a rough surface, locally characterized by sinkholes, and it has a prominent escarpment at the margin of the lower Ordovician dolomites (Buschbach, 1961). As lower Ordovician rocks are present again north of the Chicago area, the uplift may represent an early movement along the Kankakee Arch. The unconformity is exposed in the La Salle and Ottawa areas to the west, but it is 300 to 1,000 feet deep in the Chicago area.

The next younger major unconformity is at the base of the Middle Devonian rocks, where it forms the upper boundary for the middle and upper Ordovician, Silurian, and Lower Devonian sediments that compose the Tippecanoe Sequence. Although a widespread but minor unconformity occurs at the base of the upper Ordovician (Cincinnatian) rocks, the surface of the unconformity is nearly flat and only slightly truncates the middle Ordovician rocks.

The end of Ordovician time was marked by uplift, and valleys were cut as much as 150 feet deep in the shale of the upper Ordovician Maquoketa Group. The valleys were filled with early Silurian sediments, but between the valleys there is only slight evidence of unconformity. There is no significant variation in the dip of the rocks, and this unconformity, also, is not comparable to those bounding the Tippecanoe Sequence. In Illinois there is no evidence of an unconformity between Silurian and Lower Devonian rocks in the deep part of the Illinois Basin, and sedimentation apparently was continuous.

The sub-Middle Devonian unconformity at the top of the Tippecanoe Sequence is related to an interval of active tectonic movements in the Appalachian region. As a result of tilting and erosion, the Middle Devonian sediments truncate the Lower Devonian, the upper Silurian (Cayugan), and part of the middle Silurian (Niagaran) rocks north of central Illinois (fig. 6). On local areas of greater uplift, the Middle Devonian strata completely truncate the Silurian and rest on upper Ordovician rocks. In the Chicago area the Middle Devonian strata have been entirely eroded, but the position of the basal unconformity may not have been far above the youngest Silurian in the region. Overlapping Upper Devonian black shale has been found in local pockets on top of the Silurian dolomite and is probably present in the Des Plaines Disturbance. Teeth of Devonian or Mississippian sharks have been found in crevices in the dolomite (fig. 11B). Although Middle Devonian rocks occur both north and south of the Chicago area, Upper Devonian and Mississippian age rocks rest directly on the Silurian in the fault blocks of the Des Plaines Disturbance (fig. 13), and the Chicago area either remained above sea level following the sub-Middle Devonian uplift, or the Middle Devonian rocks were deposited and truncated before or during Upper Devonian time. In either case, the relations appear to result from an uplift of the Kankakee Arch.

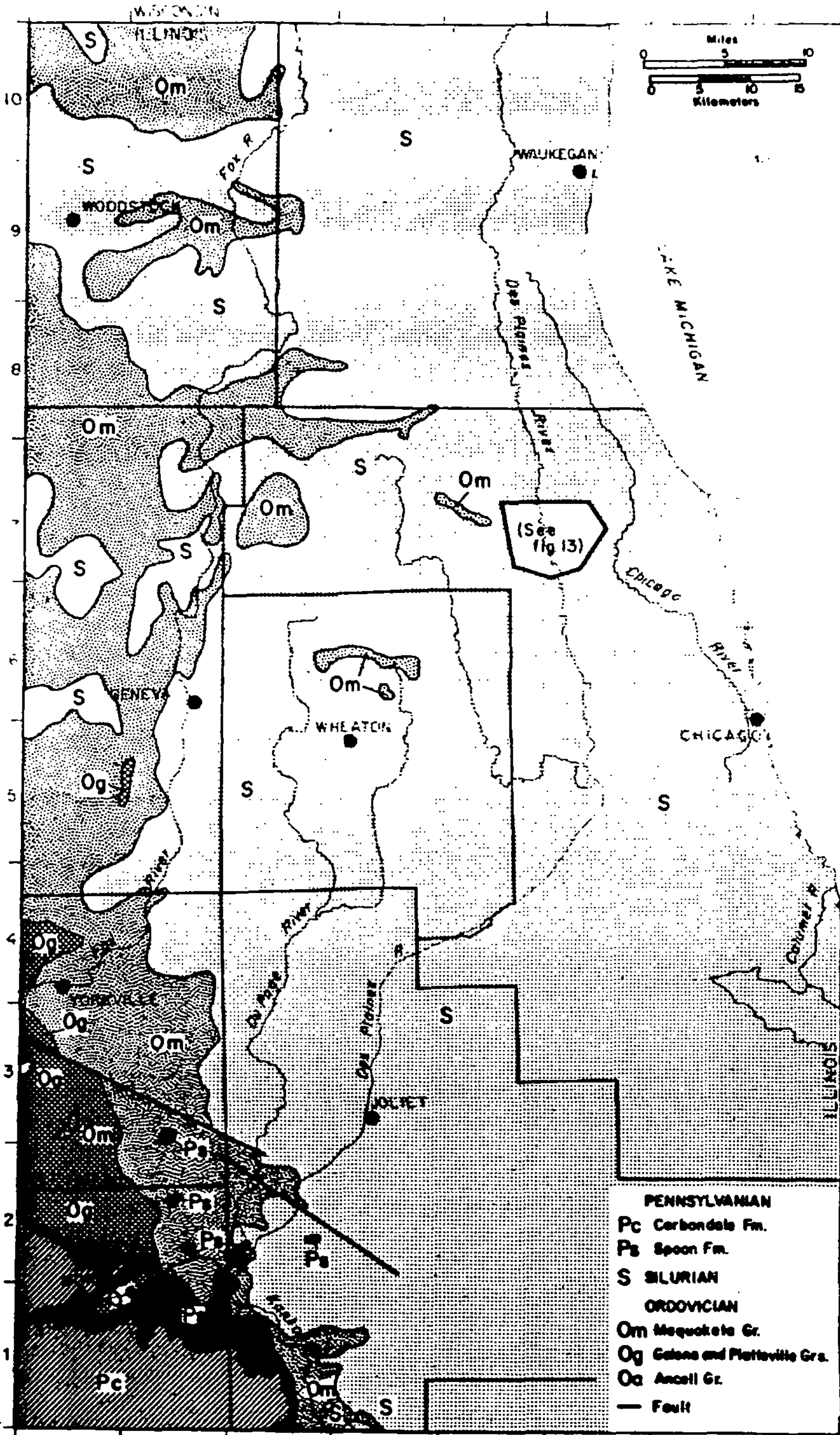

Fig. 9 - Geologic map of the bedrock surface (after Willman and others, 1967).

ranges from 5 to 50 feet thick. The limestone contains a variety of fossils, with the brachiopod *Rafinesquina* (fig. 8) particularly abundant.

Brainard Shale - The Brainard Shale consists of greenish gray shale that is generally dolomitic and in places grades into silty argillaceous dolomite. It has a maximum thickness of 100 feet, but in some localities it is entirely truncated by the sub-Silurian unconformity. The Brainard is exposed on the east side of the Des Plaines Valley along the Atchison, Topeka, and Santa Fe Railroad 2 miles north of Millsdale and along the Du Page River and Rock Run 2 miles north of Channahon (Channahon Quad.).

Neda Formation - The Neda Formation consists of beds of hematite oolites interbedded with red and gray shale. It is present only where the Brainard Shale is thick, and in many parts of the area it was eroded away along the sub-Silurian unconformity (Workman, 1950). The formation has a maximum thickness of 15 feet. It is exposed along the Kankakee River in the Kankakee River State Park campground about 2 miles south of the Chicago area.

SILURIAN SYSTEM

The Silurian System, like the Ordovician, consists of deposits in the shallow interior sea. The strata are almost entirely dolomite that varies from extremely argillaceous, silty, and cherty to exceptionally pure. The lower part of the system consists of distinctive units that have lateral continuity throughout the region. The upper part is characterized by reefs of pure dolomite surrounded by well bedded, slightly argillaceous to very impure and generally cherty dolomite.

The entire Silurian System in the Chicago area was called Niagaran dolomite in early reports, but it now is differentiated into two series — the Alexandrian Series below and the Niagaran Series above (fig. 5). They are separated by a minor interruption in sedimentation. The upper Silurian Cayugan Series is not present in the area. The Silurian rocks are part of the Hunton Megagroup that farther south includes Devonian limestone and dolomite. Silurian strata crop out at many places in the southern half of the Chicago area (pl. 1). They were described by Fisher (1925); Savage (1926); Bretz (1939); Willman (1943, 1962); Lowenstam (1948, 1949); and others.

The Silurian System has a maximum thickness of nearly 500 feet in the southeastern part of the region (Suter et al., 1959, fig. 27). The top is eroded, but it is not far below the overlapping Devonian sediments that occur a short distance east in Indiana. Because of the eastward dip of the formations, the present bedrock surface successively truncates the Silurian formations from Lake Michigan westward to the margin of the Silurian rocks in the western part of the area. Much of this truncation was probably accomplished during the formation of the sub-Middle Devonian unconformity, because the Silurian strata are only 230 feet or less thick in the Des Plaines Disturbance (fig. 13) where they are overlain by shale of Upper Devonian-Mississippian age.

The Silurian rocks are generally fossiliferous, those in the reefs abundantly so (figs. 7 and 8). However, the fossils are preserved only as casts and molds. The original calcite and aragonite shells have been largely destroyed during recrystallization to dolomite.

Alexandrian Series

The Alexandrian strata filled the deep channels eroded in the underlying Maquoketa Group and overtopped the divides between the channels. Alexandrian strata vary from only 20 feet thick along the Kankakee River to as much as 150 feet in the deeper channels in the sub-Silurian surface.

and rare, isolated sand grains. With a few minor exceptions, the reef rock contains no chert. The dolomite is medium gray, mottled with light or dark gray. Because it has a low iron content, it weathers gray. Most beds are conspicuously vuggy. In a few localities the vugs are partly filled with asphaltum, a solid petroleum residue that on hot days melts and oozes from the vugs on quarry faces.

The reefs are surrounded by argillaceous and silty dolomite, and lenses of green shale are locally present. In contrast to the dolomite of the reefs, the interreef rock is fine grained, dense, commonly cherty, light brownish gray, and weathers brown. Small reefs consisting of lenses of massive, pure dolomite occur on the slopes of the major reefs and in the interreef beds.

The larger reefs have a central area, or core, of massive to irregularly bedded dolomite (fig. 10E). The marginal areas, broader than the core in some reefs, consist of dipping beds, called flank beds (fig. 10F). The flank beds entirely surround some reefs and show the successive stages of outward growth of the reef, partly by growth of reef-building organisms on the outer slope of the reef, partly by deposition of debris eroded by waves and washed down the flank. The beds dip as much as 30 degrees, but at their outer margin they flatten and grade into argillaceous interreef types of sediments. In places the argillaceous beds continue short distances up the flanks, showing intermittent encroachment of the interreef sediments. When the reefs ceased to grow, they were entirely overlapped by the argillaceous sediments.

The lowest base of a large reef is at the top of the Joliet Formation. Other reefs start at higher positions (fig. 11A). Some extend to the top of the Racine Formation and probably extended higher before being eroded along the sub-Middle Devonian unconformity.

A large reef has been progressively exposed during development of the quarry of the Material Service (General Dynamics) Corporation at Thornton (Harvey and Calumet City Quads.). The transition from the reef core through reef flank deposits and marginal reefs (fore reefs) to interreef rocks is well exposed, and the lithology, structure, and paleontology of the reef have been described in numerous reports (Bretz, 1939; Lowenstam, 1950; Lowenstam, Willman and Swann, 1956; Willman, 1962; Ingels, 1963).

DEVONIAN SYSTEM

Rocks of Devonian age are present in the Chicago area beneath Lake Michigan, only a few miles offshore, and the entire area was probably covered by several hundred feet of Devonian rocks that were deposited in the middle and late Devonian seas. Devonian limestone overlain by black shale occurs in Indiana only a short distance east of the Illinois-Indiana state line. Black shale, probably the Grassy Creek Shale of Upper Devonian age, has been found in pockets on top of the Silurian dolomite at Elmhurst. Shale in joints in the Silurian Dolomite in the Thornton reef contains sharks' teeth that are Devonian or Mississippian in age (Bretz, 1939) (fig. 11B). The shale assigned to the Mississippian Hannibal Formation in the fault blocks of the Des Plaines Disturbance (fig. 13) may be equivalent to the Ellsworth Formation of Michigan and Northern Indiana, in which case only the uppermost part is Mississippian and the lower part is late Devonian in age (J. A. Lineback, personal communication).

MISSISSIPPIAN SYSTEM

Rocks of Mississippian age at one time probably covered the entire Chicago area, but they are now present only in the fault blocks of the Des Plaines Disturbance and are not exposed (fig. 13). In the fault blocks as much as 500 feet of shale and siltstone is assigned to the Hannibal Shale of early Mississippian (Kinderhookian) age, although, as previously noted, it may include a large proportion of late Devonian shale. The shale is overlain by 200 feet of cherty limestone, the Burlington-Keokuk Limestone of middle Mississippian (Valmeyeran) age. The Devonian-Mississippian rocks overlie Silurian dolomite and are overlain by Pennsylvanian shale. As Pennsylvanian strata rest directly on pre-Devonian rocks in the southern part of the area and for 50 miles farther southwest, the preservation of the Devonian and Mississippian rocks on the high part of the Kankakee Arch is anomalous, and it suggests that there may have been faulting in the Des Plaines structure in late Mississippian or early Pennsylvanian time.

PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian System were originally called "Coal Measures" because they contain the important coal seams. Pennsylvanian rocks underlie the southwestern corner of the Chicago area (fig. 9) and are well exposed along the Mazon River (Coal City Quad.), along Waupecan Creek (Morris Quad.), in the coal strip mines near Coal City, and along the lower few miles of the Kankakee River (Coal City and Wilmington Quads.) (pl. 1). Pennsylvanian rocks formerly covered the entire Chicago area. They have been eroded from the area north and east of Joliet, except in the Des Plaines Disturbance where they occur in a fault block (fig. 13). They are the youngest bedrock formations exposed in the Chicago area and belong to the Desmoinesian Series. They were deposited during the middle part of the Pennsylvanian Period. However, in a few localities the basal Pennsylvanian strata may belong to the older Atokan Series.

The Pennsylvanian rocks are largely shale and sandstone, but they differ notably from the older Paleozoic formations, which are largely thick units dominated by a single rock type — dolomite, sandstone, or shale. The Pennsylvanian succession consists of much thinner units and many more types of rock.

During Pennsylvanian time the sea repeatedly advanced over the area from the south. Consequently, the deposits are alternately marine and nonmarine. The deposits of a marine-nonmarine cycle are called a cyclothem and are generally arranged in the same order in successive cyclothems. The base of a typical cyclothem is fine-grained, silty, micaceous sandstone or sandy siltstone, overlain successively by sandy shale, nodular limestone, claystone (also called underclay), coal, and gray shale. These are the nonmarine units of the cyclothem. In some areas the gray shale at the top is a marine or brackish-water deposit. Above the gray shale, or where it is absent, resting directly on the coal, is a black, slate-like shale that contains marine fossils and, in places, large oval concretions of limestone. The black shale is overlain by fossiliferous, gray, slightly argillaceous limestone or by limestone and calcareous shale interbedded. Above the limestone is a gray shale, the lower part of which generally contains marine fossils. These are the marine units in the cyclothem Above the gray shale is the sandstone that forms the basal unit of the next higher cyclothem. In places the sandstone fills channels that cut into the shale and locally extend down to the coal or below.

Successive cyclothems are never identical, because some units are missing and units that correspond differ in thickness and in minor lithologic characteristics. The cyclothems vary from a few to 75 feet thick, depending largely on the thickness of the sandstones and the degree to which they truncate the underlying cyclothems.

Parts of three cyclothems are exposed along the Mazon River near the mouth of Johnny Run (Coal City Quad.) and along Waupecan Creek for a mile south of the Boy Scout Camp (Morris Quad.) (fig. 10A). In both of these areas the section exposed begins with the Vermilionville Sandstone Member, which is the basal unit of the Brereton Cyclothem, and extends downward through the St. David and Summum Cyclothems. The St. David Cyclothem lacks a coal and a basal sandstone in this area. The position of the sandstone is occupied by a distinctive but thin bed of

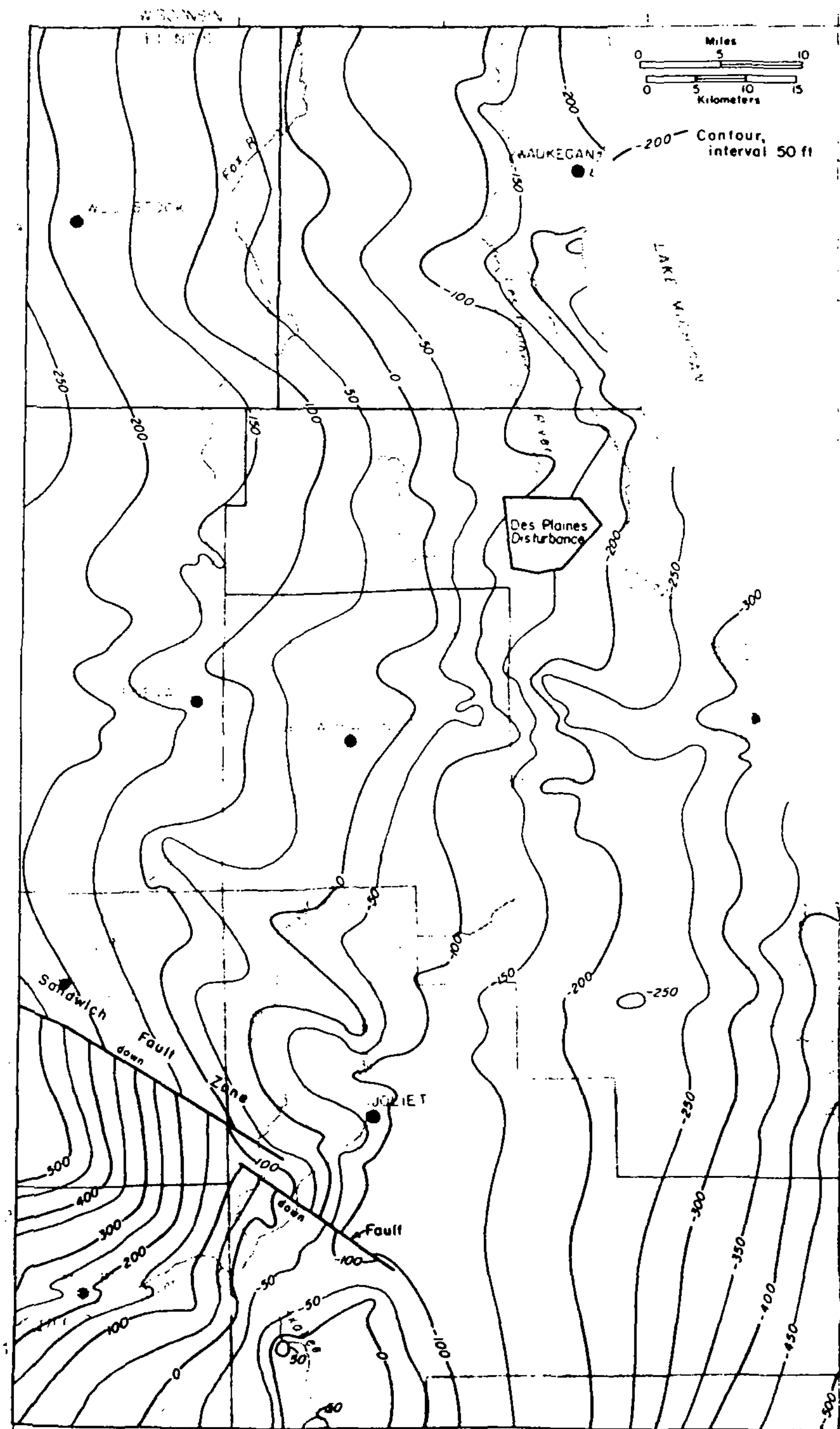

Fig. 12 - Geologic structure of the Chicago area. Contours on top of the Glenwood and St. Peter Sandstones (after Buschbach, 1964).

the Platteville Group (fig. 5). The top of the Glenwood Formation is more than 500 feet above sea level in the southwestern part of the area, but it is 500 feet below sea level in the southeastern corner, a decline of 1,000 feet in 50 miles and an average of 20 feet per mile. Throughout most of the Chicago area the dip is 10 to 15 feet per mile.

Sandwich Fault Zone

The Sandwich Fault Zone (fig. 12) extends southeastward from the vicinty of Oregon for a distance of about 80 miles, into the southern part of the Chicago area (Willman and Templeton, 1951; Suter et al., 1959; Buschbach, 1964; Willman and others, 1967). Where exposed near its northwestern end, the fault is about 100 feet wide and the rocks are intensely sheared. The bordering rocks are broken by many faults that have small displacements. The fault zone appears to be nearly vertical and, relative to each other, the rocks on the north side were moved down and those on the south side were moved up. The drag, or upward bend, of the rocks on the downthrown side of the fault is exposed along the Fox River at Millhurst, 2 miles west of the boundary of the Chicago area. The maximum displacement of the beds is 900 feet 20 to 30 miles west of the Chicago area, but near the ends of the fault, the displacement diminishes abruptly. At the western edge of the Chicago area, the displacement is about 250 feet, which decreases eastward to zero in about 18 miles.

A few miles farther east on nearly the same alignment, a fault that has a maximum displacement of about 100 feet has the downthrown side on the south. If it is directly connected with the Sandwich Fault Zone, only a scissors-like movement on the fault plane can explain the difference in direction of displacement. The eastern fault is generally interpreted as a parallel fault slightly offset to the south. The place where it crosses the Des Plaines Valley is shown on plate 1. The fault plane is not exposed, but the change from Ordovician rocks north of the fault to Silurian at the same level on the south can be observed (Channahon Quad.).

The youngest rocks broken by the Sandwich Fault Zone are Silurian in age, and the faulting, therefore, is younger than Silurian. Although Pennsylvanian rocks have been eroded from the Sandwich Fault Zone, major folding and faulting west and south of the Chicago area involved Pennsylvanian rocks. The fault zone therefore may be post-Pennsylvanian in age, and it most likely is related to the major disturbance at the end of the Paleozoic Era.

Des Plaines Disturbance

The Des Plaines Disturbance (fig. 13) is an unusual structural feature, the origin of which has aroused much discussion. At Des Plaines in northwestern Cook County, the rocks in an area about 5½ miles in diameter are intensely faulted. Displacements as much as 600 feet bring rocks as old as the St. Peter Sandstone and Oneota Dolomite to the bedrock surface in the central part of the structure and carry downward Mississippian and Pennsylvanian strata that are not present elsewhere in the region nearer than 50 miles. The disturbance is surrounded by nearly horizontal Silurian dolomite in which drilling has revealed no faults.

The description and interpretation of the structure by Emrich and Bergstrom (1962) are based on the records of 295 wells and the study of samples from 102 of the wells. The wells provide all the information that is available. The bedrock is buried beneath 75 to 200 feet of glacial drift, and there is no indication of the structure on the present surface. The structure is probably even more complex than is indicated by the drill data.

The intensity of the deformation in a local, roughly circular area relates the structure to others widely scattered through the Midwest that are called cryptoex-

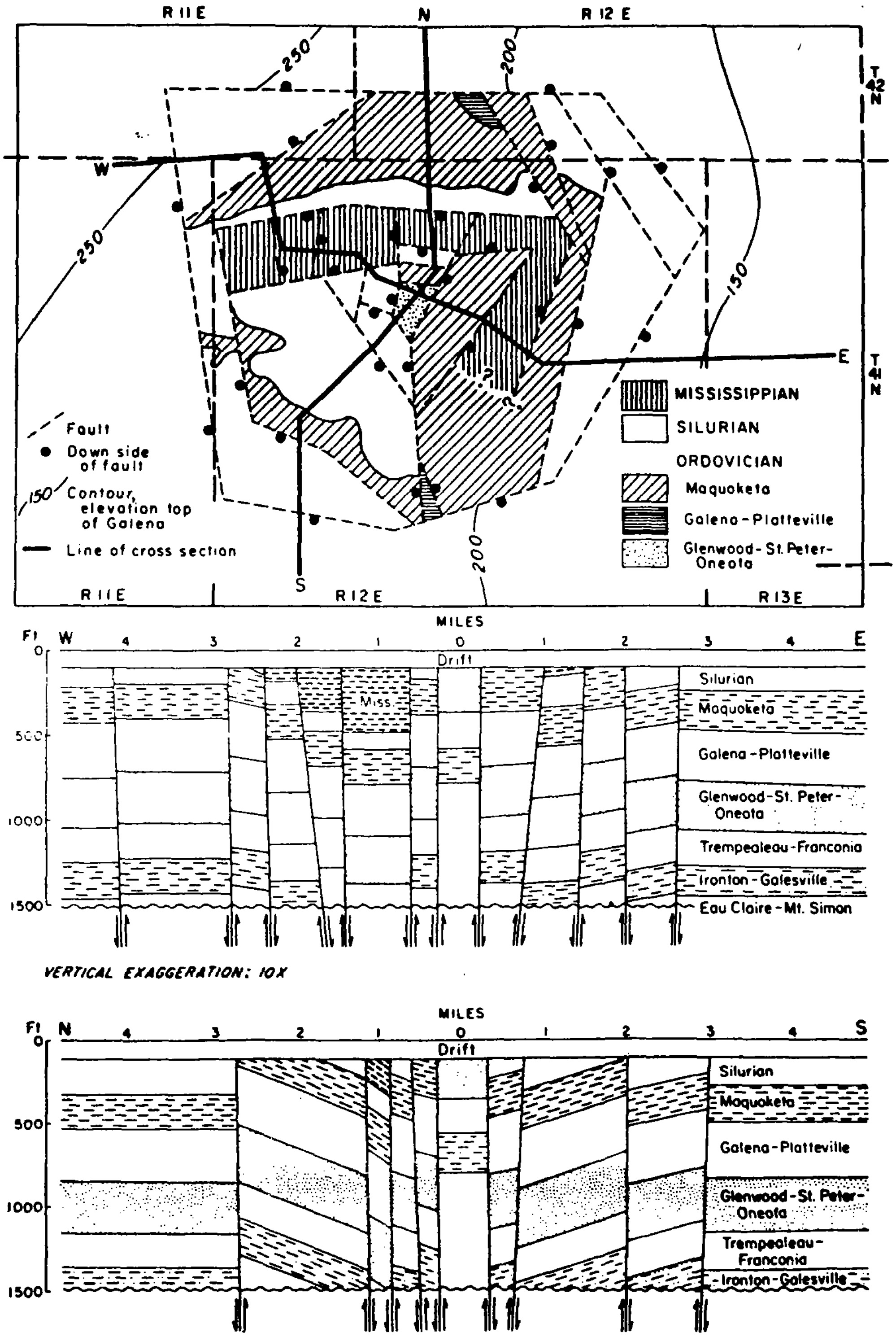

Fig. 13 - Geologic map and cross sections of the Des Plaines Disturbance (after Emrich and Bergstrom, 1962).

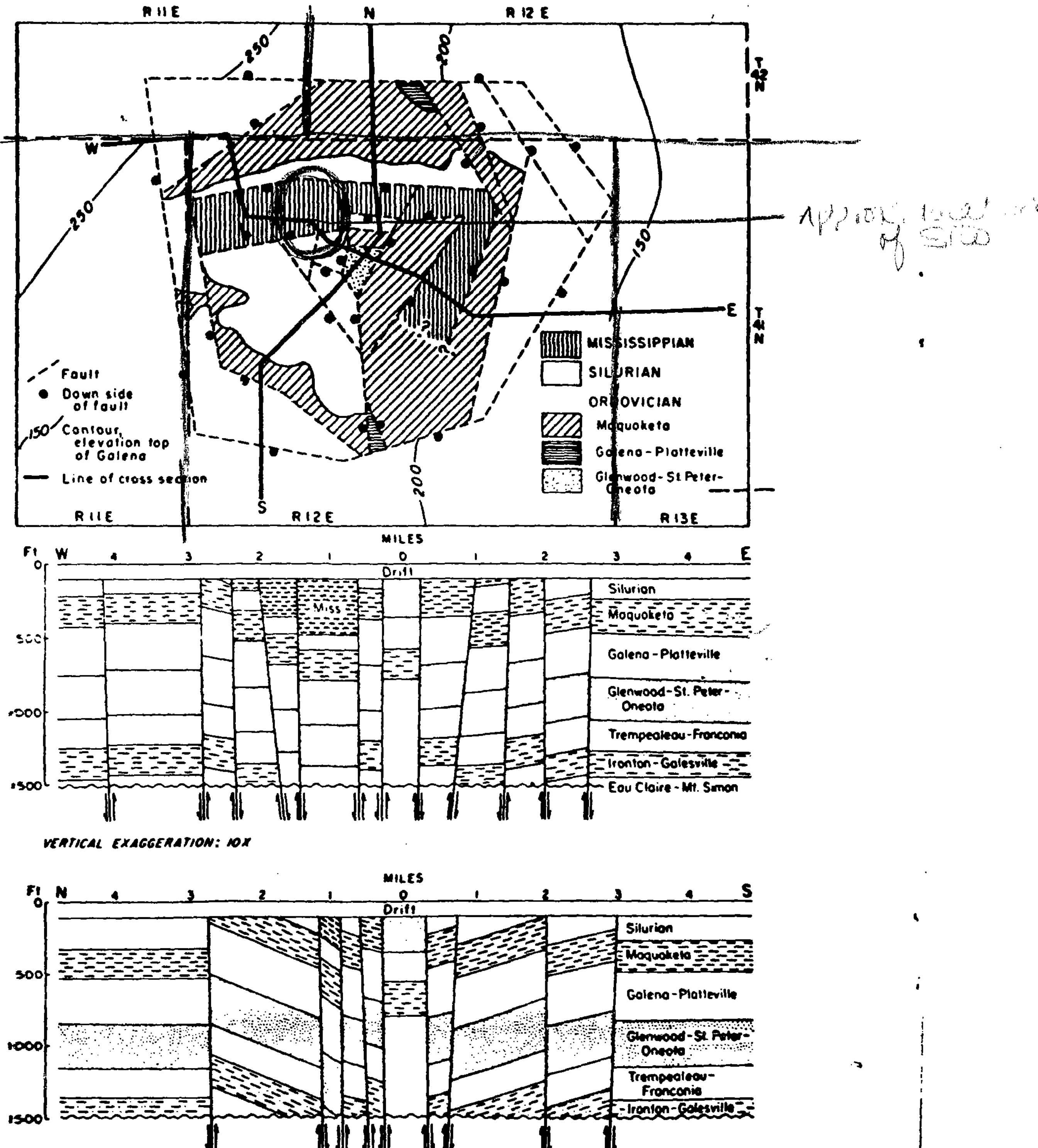

Fig. 13 - Geologic map and cross sections of the Des Plaines Disturbance (after Emrich and Bergstrom, 1962).

plosion structures. Earlier these structures were thought to be formed by the sudden release of gases from below and were called cryptovolcanic structures. More recently shatter cones, minerals formed only at very high pressures, and explosion breccias have been found in many of the other structures. This evidence suggests that these structures were formed by the impact of meteorites.

Because the Des Plaines structure is not exposed, these features are not observable, and they have not been found in the few available cores. Furthermore, the faults appear to be essentially vertical. In most wells a normal sequence is found below whatever the uppermost rock happens to be, which suggests that the beds in the fault blocks are nearly horizontal (fig. 13). In other structures more definitely formed by meteorite impact, the beds in many of the fault blocks are nearly vertical. Although the Des Plaines structure, like the others, has a central uplift, the intensity of deformation is much less. If the Des Plaines Disturbance is the result of a meteorite impact, it may be only the lower part of the deformed zone, where the deformation was diminishing. More than 1,000 feet of younger Paleozoic rocks, now absent, could have been present over the Silurian strata in this area near the end of the Paleozoic Era.

As Pennsylvanian rocks are present in the structure, it is late Pennsylvanian or younger in origin. However, the presence of 700 feet of late Devonian and Mississippian rocks in some of the fault blocks and their absence beneath the Pennsylvanian rocks in the southern part of the area and for 50 miles farther south suggests, although it does not prove, that some of the faulting is pre-Pennsylvanian. If the faulting occurred at more than one time, the structure was not formed by meteorite impact. Therefore, origin by meteorite impact, although favored, remains uncertain.

BEDROCK SURFACE

The surface of the bedrock (fig. 14) is an undulating plain in which steep-sloped valleys as much as 100 to 150 feet deep are entrenched (Horberg, 1950; Piskin and Bergstrom, 1967). The slopes on the bedrock surface are rarely parallel to the slopes of the present topography (fig. 20), and it is apparent that the modern rivers and streams have had little to do with formation of the bedrock surface. The glacial deposits almost completely filled the valleys in the bedrock surface, and the glaciers left their own distinctive topography. This resulted in the establishment of new drainage lines generally discordant with the earlier valleys. Except for a few miles, and there more or less accidentally, the present valleys are not reexcavated bedrock valleys.

The surface of the bedrock is the sub-Pleistocene unconformity. It truncates the Paleozoic formations (fig. 9), and the influence of differences in hardness, or resistance to erosion, is evident only locally. The surface passes from the Silurian and Ordovician dolomites westward to the shale of the Maquoketa Group and southwestward to the Pennsylvanian sandstones and shales, but the boundaries are not apparent on the bedrock surface map (fig. 14). The bedrock surface drainage divide (fig. 21), which would separate the Great Lakes and Mississippi River drainage if it were the present surface, is on the Silurian dolomite in the southern part of the area, but it turns westward onto the Maquoketa Shale in the central western part.

Although the beveled surface of the bedrock formations may be attributed partly to inheritance from older erosional surfaces, the surface is fresh and unweathered under the glacial drift. The preglacial surface probably was shaped and generally lowered, perhaps 100 feet or more, by glacial erosion. The sharp valleys in the bedrock surface are the lower parts of deeper valleys that were cut during the Sangamonian Stage of deglaciation, or possibly earlier, were then truncated by the Wisconsinan glaciers, and were finally filled with Wisconsinan drift.

A deep buried valley extending northeastward from Joliet (fig. 14) is called Hadley Valley (Horberg and Emery, 1943; Bretz, 1955; Suter et al., 1959). At the

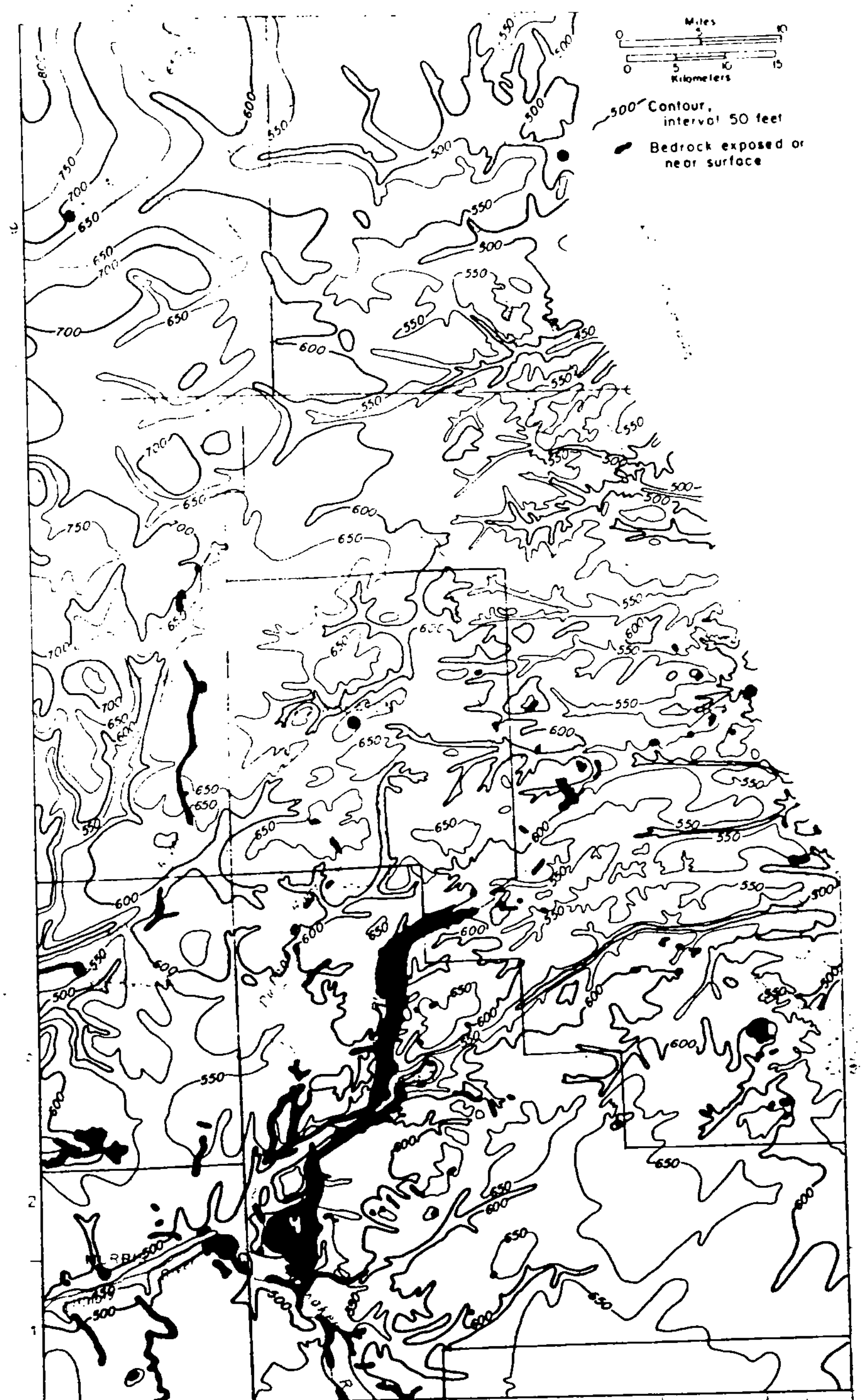

Fig. 14 - Topographic map of the bedrock surface (after Suter et al., 1959).

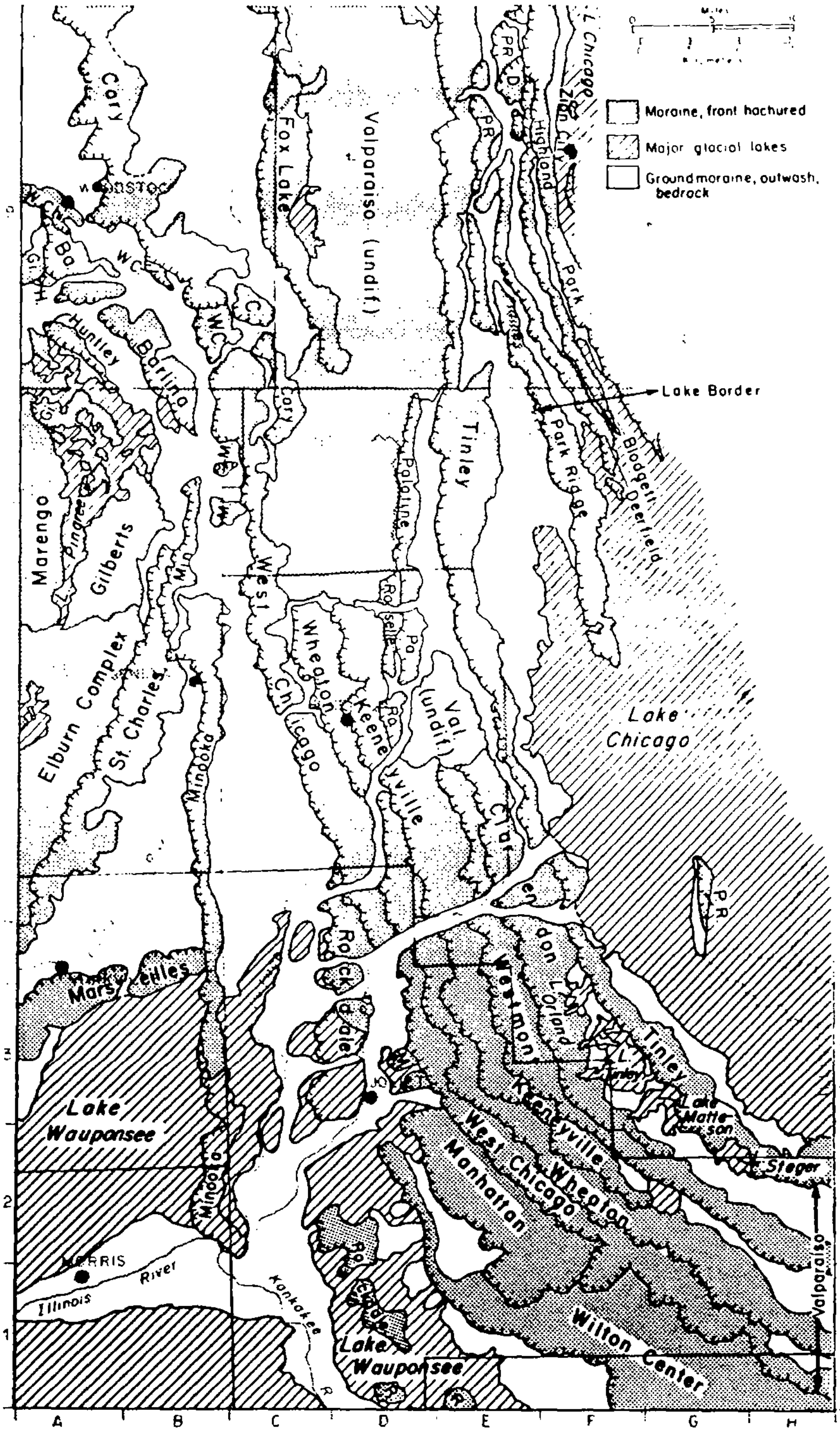

Fig. 16 - Major glacial features of the Chicago area.

Ground Water

The water supplies of the Chicago area come largely from Lake Michigan and from wells that tap ground-water resources. The smaller lakes in the area are a source of water for some communities. Artificial lakes provide limited quantities of water for local use. The rivers and streams supply little water suitable for uses other than cooling in power plants. A limited amount of water is diverted from Lake Michigan to maintain flow through the Chicago Sanitary and Ship Canal.

The ground-water resources are in four major water-yielding units, called aquifers: (1) sand and gravel beds in the glacial drift; (2) the Shallow Dolomite Aquifer, mainly the Silurian dolomite; (3) the Cambrian-Ordovician Aquifer, in which the Ironton-Galesville and Glenwood-St. Peter Sandstones are the most productive units; and (4) the Mt. Simon Aquifer, which consists of the Mt. Simon Sandstone and the basal sandstone of the Eau Claire Formation (Suter et al., 1959).

The shallow aquifers are connected hydrologically and are recharged directly by seepage from precipitation. They are separated by the relatively impervious Maquoketa Group Shale from the Cambrian-Ordovician Aquifer. The Cambrian-Ordovician Aquifer rises westward and it is recharged at the surface or through glacial deposits west of the outcrop area of the Maquoketa Group Shale along the western side of the Chicago area (fig. 9). The Cambrian-Ordovician Aquifer is separated from the Mt. Simon Aquifer by the shaly and silty beds of the Eau Claire Formation that prevent flow between the aquifers. The Mt. Simon Aquifer has a higher artesian pressure than the other aquifers, but the water quality in the eastern part of the area is not acceptable for many uses. It is recharged largely from the outcrop region of Cambrian rocks in central southern Wisconsin (fig. 1).

The Cambrian-Ordovician Aquifer has been the most highly developed bedrock aquifer. Artesian pressure in the aquifer caused the first deep well drilled in Chicago to flow with a head 80 feet above the surface, but by 1959 the water surface had declined as much as 660 feet in a cone-shaped region around the area of heaviest pumping. On the other hand, about 60 percent of the total pumpage in the area is from the two shallow aquifers, and in them there is no widespread decline in water levels.

The geology, hydrology, and resources of ground water in the Chicago area have been discussed in detail by Suter et al. (1959) and Zeizel et al. (1962).

ENGINEERING GEOLOGY

The design of buildings, roads, dams, bridges, and subways — in fact, of all kinds of structures — is dependent on the properties and variations of the geological formations on or in which they are built. Specific conditions at each site must be evaluated for the particular structure being planned. The engineering geologist may employ test drilling, rock core and soil sample studies, and in some instances geophysical logging and laboratory testing, to evaluate the geologic conditions that must be considered in design and construction.

Major engineering problems in the Chicago area have included the design of foundations for skyscrapers, most of which require excavation through 50 feet or more of glacial deposits (largely till but including water-bearing sands and boulder accumulations) to an uneven bedrock surface. Large buildings in areas of deeper drift are placed on piling, generally driven to bedrock. Glacial till provides adequate foundations for smaller buildings and most houses.

Construction of the Chicago subway involved many problems concerned with variations in the properties of the glacial drift (Peck and Reed, 1954). Similar problems are involved in highway and bridge design and in the construction of dams (W. C. Smith, 1968, 1969). Study of the variations in the glacial drift has been important in constructing foundations for the 200 BEV accelerator at the Na-

Des Plaines
Disturbance

the Platteville Group (fig. 5). The top of the Glenwood Formation is more than 500 feet above sea level in the southwestern part of the area, but it is 500 feet below sea level in the southeastern corner, a decline of 1,000 feet in 50 miles and an average of 20 feet per mile. Throughout most of the Chicago area the dip is 10 to 15 feet per mile.

Sandwich Fault Zone

The Sandwich Fault Zone (fig. 12) extends southeastward from the vicinty of Oregon for a distance of about 80 miles, into the southern part of the Chicago area (Willman and Templeton, 1951; Suter et al., 1959; Buschbach, 1964; Willman and others, 1967). Where exposed near its northwestern end, the fault is about 100 feet wide and the rocks are intensely sheared. The bordering rocks are broken by many faults that have small displacements. The fault zone appears to be nearly vertical and, relative to each other, the rocks on the north side were moved down and those on the south side were moved up. The drag, or upward bend, of the rocks on the downthrown side of the fault is exposed along the Fox River at Millhurst, 2 miles west of the boundary of the Chicago area. The maximum displacement of the beds is 900 feet 20 to 30 miles west of the Chicago area, but near the ends of the fault, the displacement diminishes abruptly. At the western edge of the Chicago area, the displacement is about 250 feet, which decreases eastward to zero in about 18 miles.

A few miles farther east on nearly the same alignment, a fault that has a maximum displacement of about 100 feet has the downthrown side on the south. If it is directly connected with the Sandwich Fault Zone, only a scissors-like movement on the fault plane can explain the difference in direction of displacement. The eastern fault is generally interpreted as a parallel fault slightly offset to the south. The place where it crosses the Des Plaines Valley is shown on plate 1. The fault plane is not exposed, but the change from Ordovician rocks north of the fault to Silurian at the same level on the south can be observed (Channahon Quad.).

The youngest rocks broken by the Sandwich Fault Zone are Silurian in age, and the faulting, therefore, is younger than Silurian. Although Pennsylvanian rocks have been eroded from the Sandwich Fault Zone, major folding and faulting west and south of the Chicago area involved Pennsylvanian rocks. The fault zone therefore may be post-Pennsylvanian in age, and it most likely is related to the major disturbance at the end of the Paleozoic Era.

Des Plaines Disturbance

The Des Plaines Disturbance (fig. 13) is an unusual structural feature, the origin of which has aroused much discussion. At Des Plaines in northwestern Cook County, the rocks in an area about 5½ miles in diameter are intensely faulted. Displacements as much as 600 feet bring rocks as old as the St. Peter Sandstone and Oneota Dolomite to the bedrock surface in the central part of the structure and carry downward Mississippian and Pennsylvanian strata that are not present elsewhere in the region nearer than 50 miles. The disturbance is surrounded by nearly horizontal Silurian dolomite in which drilling has revealed no faults.

The description and interpretation of the structure by Emrich and Bergstrom (1962) are based on the records of 295 wells and the study of samples from 102 of the wells. The wells provide all the information that is available. The bedrock is buried beneath 75 to 200 feet of glacial drift, and there is no indication of the structure on the present surface. The structure is probably even more complex than is indicated by the drill data.

The intensity of the deformation in a local, roughly circular area relates the structure to others widely scattered through the Midwest that are called cryptoexplosion structures. Earlier these structures were thought to be formed by the sudden release of gases from below and were called cryptovolcanic structures. More recently shatter cones, minerals formed only at very high pressures, and explosion breccias have been found in many of the other structures. This evidence suggests that these structures were formed by the impact of meteorites.

Because the Des Plaines structure is not exposed, these features are not observable, and they have not been found in the few available cores. Furthermore, the faults appear to be essentially vertical. In most wells a normal sequence is found below whatever the uppermost rock happens to be, which suggests that the beds in the fault blocks are nearly horizontal (fig. 13). In other structures more definitely formed by meteorite impact, the beds in many of the fault blocks are nearly vertical. Although the Des Plaines structure, like the others, has a central uplift, the intensity of deformation is much less. If the Des Plaines Disturbance is the result of a meteorite impact, it may be only the lower part of the deformed zone, where the deformation was diminishing. More than 1,000 feet of younger Paleozoic rocks, now absent, could have been present over the Silurian strata in this area near the end of the Paleozoic Era.

As Pennsylvanian rocks are present in the structure, it is late Pennsylvanian or younger in origin. However, the presence of 700 feet of late Devonian and Mississippian rocks in some of the fault blocks and their absence beneath the Pennsylvanian rocks in the southern part of the area and for 50 miles farther south suggests, although it does not prove, that some of the faulting is pre-Pennsylvanian. If the faulting occurred at more than one time, the structure was not formed by meteorite impact. Therefore, origin by meteorite impact, although favored, remains uncertain.

BEDROCK SURFACE

The surface of the bedrock (fig. 14) is an undulating plain in which steep-sloped valleys as much as 100 to 150 feet deep are entrenched (Horberg, 1950; Piskin and Bergstrom, 1967). The slopes on the bedrock surface are rarely parallel to the slopes of the present topography (fig. 20), and it is apparent that the modern rivers and streams have had little to do with formation of the bedrock surface. The glacial deposits almost completely filled the valleys in the bedrock surface, and the glaciers left their own distinctive topography. This resulted in the establishment of new drainage lines generally discordant with the earlier valleys. Except for a few miles, and there more or less accidentally, the present valleys are not reexcavated bedrock valleys.

The surface of the bedrock is the sub-Pleistocene unconformity. It truncates the Paleozoic formations (fig. 9), and the influence of differences in hardness, or resistance to erosion, is evident only locally. The surface passes from the Silurian and Ordovician dolomites westward to the shale of the Maquoketa Group and southwestward to the Pennsylvanian sandstones and shales, but the boundaries are not apparent on the bedrock surface map (fig. 14). The bedrock surface drainage divide (fig. 21), which would separate the Great Lakes and Mississippi River drainage if it were the present surface, is on the Silurian dolomite in the southern part of the area, but it turns westward onto the Maquoketa Shale in the central western part.

Although the beveled surface of the bedrock formations may be attributed partly to inheritance from older erosional surfaces, the surface is fresh and unweathered under the glacial drift. The preglacial surface probably was shaped and generally lowered, perhaps 100 feet or more, by glacial erosion. The sharp valleys in the bedrock surface are the lower parts of deeper valleys that were cut during the Sangamonian Stage of deglaciation, or possibly earlier, were then truncated by the Wisconsinan glaciers, and were finally filled with Wisconsinan drift.

A deep buried valley extending northeastward from Joliet (fig. 14) is called Hadley Valley (Horberg and Emery, 1943; Bretz, 1955; Suter et al., 1959). At the

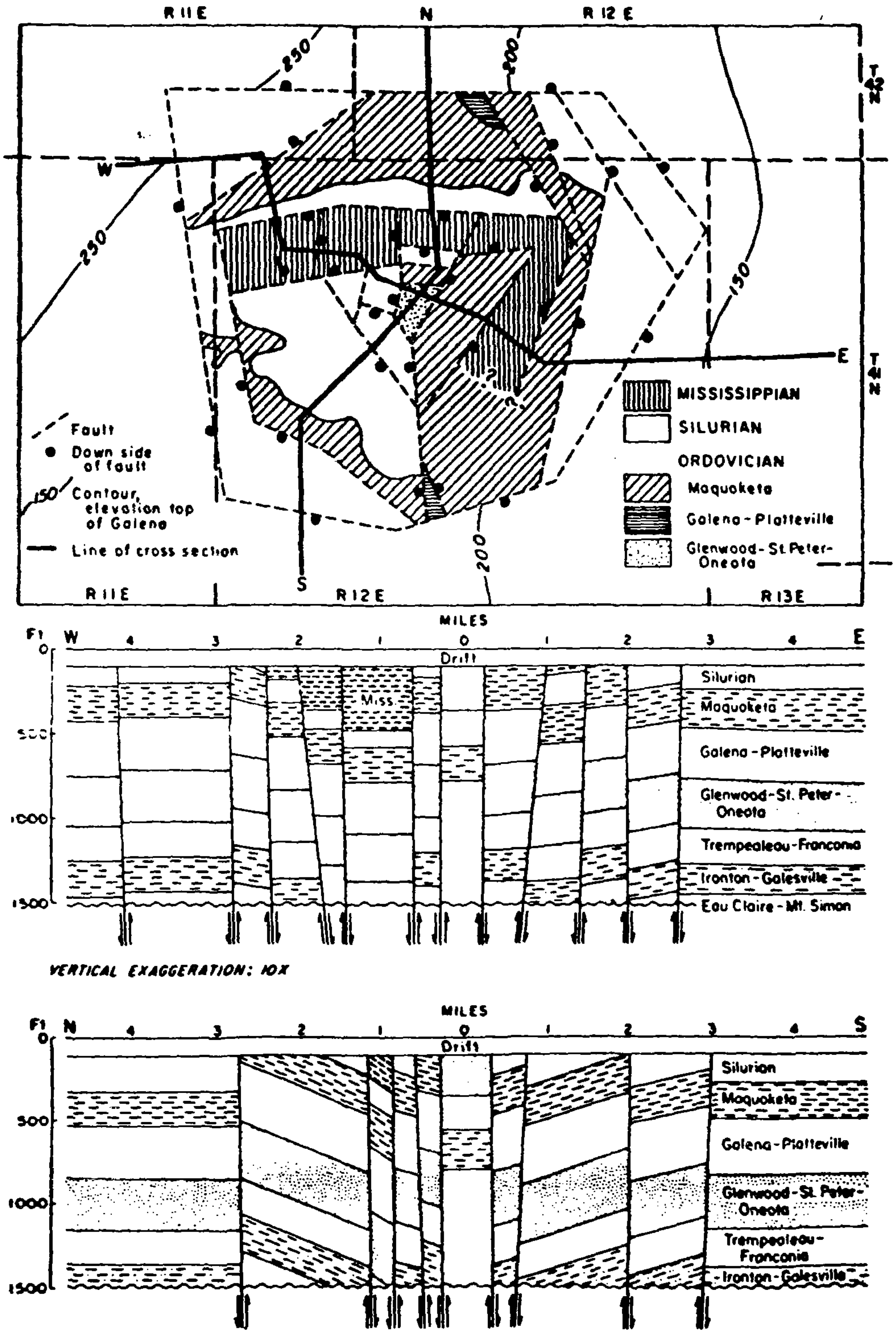

Fig. 13 - Geologic map and cross sections of the Des Plaines Disturbance (after Emrich and Bergstrom, 1962).

SYSTEM	SERIES	GROUP OR FORMATION	GRAPHIC LOG	THICKNESS (FEET)	DESCRIPTION	WATER YIELDING PROPERTIES	AQUIFERS
QUATERNARY	PLEISTOCENE			0 - 400+	Unconsolidated ice - and water-laid deposits, pebbly clay (till), silt, sand and gravel, generally discontinuous and interbedded; alluvial silts and sands commonly present along streams	Yields of wells variable, some well yields greater than 1000 gpm	Glacial drift aquifers
PENNSYLVANIAN				0 - 175	Shale; sandstones, fine grained; limestone; coal; clay	Generally not water yielding	Shallow bedrock aquifers
MISSISSIPPIAN DEVONIAN* / SILURIAN	NIAGARAN			0 - 400+	Dolomite, very pure to very silty, cherty; shale partings; thin shales and argillaceous beds frequently present in lower parts of Silurian dolomite	Yields of wells variable, some well yields greater than 1000 gpm	
	ALEXANDRIAN			0 - 165	Upper and middle units - shale, light gray to green, plastic to brittle, some dolomite, silty; *dolomite, mostly silty, argillaceous; minor* limestone		
ORDOVICIAN	CINCINNATIAN	Maquoketa		0 - 250+	Lower unit - shale, dark gray, black, brown, plastic to brittle; some dolomite in upper part; silty, argillaceous	Generally not water yielding, acts as barrier between shallow and deep aquifers	
	CHAMPLAINIAN	Galena Platteville		150 - 350+	Dolomite, cherty; sandy at base; limestone; shale partings	Water yielding where not capped by shales	Cambrian-Ordovician aquifer
		Glenwood St. Peter		75 - 650	Sandstone, fine to coarse grained; shale at top; locally cherty red shale at base	Estimated transmissivity 15 percent that of Cambrian-Ordovician aquifer	
	CANADIAN	Prairie du Chien		0 - 340	Dolomite, sandy, cherty, interbedded with sandstone	Estimated transmissivity 35 percent that of Cambrian-Ordovician aquifer	
CAMBRIAN	CROIXAN	Eminence Potosi		0 - 225	Dolomite, white, fine grained sandy at base; drusy quartz		
		Franconia		45 - 175	Sandstone, dolomite, and shale, glauconitic, green to red, micaceous		
		Ironton Galesville		103 - 275	Sandstone, fine to *medium grained*, well sorted, upper part dolomitic	*Estimated* transmissivity 50 percent that of Cambrian-Ordovician aquifer	
		Eau Claire		235 - 450	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic; dolomite, sandy	Generally not water yielding, acts as barrier between Ironton-Galesville and Mt. Simon	
		Mt. Simon		2000±	Sandstone, coarse grained, white, red in lower half; lenses of shale and siltstone, red, *micaceous*	Moderate amounts of water, permeability between that of Glenwood-St. Peter and Ironton-Galesville, water quality problem with depth of penetration	Mt. Simon aquifer
PRECAMBRIAN					Not penetrated by wells in Chicago area *Nearby wells encounter red or gray granite* or similar rocks		

* Mississippian rocks present in Des Plaines Disturbance.
Devonian rocks present as crevice fillings in Silurian rocks.

(from Hughes et al., 1966)

Figure 1. Geologic column and aquifer description of northeastern Illinois